14

THE STRATIGRAPHIC AND DIASTROPHIC EVOLUTION OF CENTRAL AND EASTERN VICTORIA IN MIDDLE PALAEOZOIC TIMES

By John A. Talent
Geological Survey of Victoria

Abstract

A mosaic of marine and non-marine sedimentation in C. and E. Victoria in Silurian and Devonian times is intimately connected with diastrophic events. These are expressed as unconformities, breaks in sedimentation, and fluctuating lithofacies relationships. More important among these are: the unconformity between the Cowombat Group and Timbarra Formation in E. Victoria; the unconformity between the Waratah Limestone and Cambrian greenstones at Waratah Bay; the unconformity between the Waratah and Bell Point limestones; the variation from near-shore McIvor and Mt Ida formations to graptolitic sediments eastwards in the early Devonian and latest Ludlovian of C. Victoria; the regression of the Lower Devonian sea from C. Victoria indicated by the Cathedral Beds; the block faulting and planation of the Snowy River Volcanics prior to deposition of the Buchan Group. The withdrawal of the Lower Devonian sea from C. Victoria more or less coincides with the onset of stable shelf sedimentation (Buchan Group) in the E. part of the State, to be followed by the Tabberabberan deformation, vulcanism, and non-marine sedimentation throughout the State.

Introduction

Biostratigraphic and structural investigations of the Middle Palaeozoic of Victoria in recent years have been directed towards elucidating the structural and stratigraphic evolution of the State (Talent 1956a, 1956b, 1959a, 1960, 1963, 1964; Teichert & Talent 1958; Philip 1960a, 1960b, 1962a; Fletcher 1963; Schleiger 1964a, 1964b; Williams 1964; Moore 1965; Couper 1965). Concurrent with this, attention has been directed towards discrimination of a succession of faunas, particularly in the more fossiliferous Ludlow-Eifelian part of the column, which it may then be possible to use for tying in sequences with structural complication or where poor exposures prevent discrimination of the stratigraphic succession. The sequence of faunas thus derived has been tied in with the standard graptolite and tentaculite sequences as far as international zones have been recognized. Discrimination of the ages of other faunas, of necessity, has been done by interpolation and, for higher horizons, by extrapolation, relying principally on the incoming of new forms of brachiopods and, to a lesser degree, on a few other invertebrates. The resultant pattern (Fig. 2), though based on a wide range of unpublished information, remains tentative and will doubtless be subject to refinement when other less widely distributed groups, principally the corals, tentaculitids, trilobites, ostracodes, and conodonts have been exhaustively monographed and evolutionary lineages worked out. Continued refining of this system should provide a useful accessory standard for correlation of Bohemian province Lower Devonian faunas elsewhere in Australia and Eurasia.

The correlations given here (Fig. 2) leave the question of the Silurian-Devonian boundary open, though of recent years the Ludlow Bone Bed has tended to be taken as the base of the Devonian. This is in harmony with the position taken by most workers involved with the classical sequences of W. Europe (e.g. White 1950) and is the position adopted by the Geological Survey of Great Britain. The Downtonian and Dittonian are therefore to be regarded as of Devonian age, their fish zones having been tied in with the Gedinnian and Siegenian of W. Europe (e.g. White 1956). The last of the graptolites, not presently known in Great Britain, accordingly extend well into the Lower Devonian (cf. Solle 1963). If international agreement can be reached to accept some standard other than the Ludlow Bone Bed as the base of the Devonian, then the correlations given here will need to be adjusted accordingly. One such historically justifiable alternative is to take the Downtonian-Dittonian boundary as the base of the Devonian (Tarlo 1964), in which case units of Skalian age would fall within the Silurian.

The development of these ideas has grown in part from palaeontological work undertaken as support to a series of mapping projects by members of the Geological Survey of Victoria: Dr D. E. Thomas, Messrs G. Bell, P. R. Kenley, B. R. Thompson, and the author; of the Royal Melbourne Institute of Technology: K. Bradley, J. Couper, R. Dale, K. Fletcher, B. Garrett, E. A. Woodford; by B. R. Moore of the University of Melbourne, and by N. W. Schleiger of the Victorian Education Department. Dr O. P. Singleton joined me in investigating the Wombat Creek Group; my colleagues, P. E. Bock, R. C. Glenie, and K. J. Reed, helped me map the Silurian-Devonian sequence of the headwaters of the Buchan, Indi, and Tambo R.; Professors Bedrich Bouček and Hermann Jaeger, and Dr D. E. Thomas have been most helpful with determinations of tentaculitids and graptolites; Mr E. D. Gill freely discussed his work on the Yering Group and his ideas on correlation of Lower Devonian brachiopod faunas in C. Victoria. Many of the ideas expressed in this synthesis have grown in an atmosphere of interest and constructive criticism from Drs O. P. Singleton and D. E. Thomas.

Stratigraphic Mosaic

Central Victoria

Broadly speaking, there are two provinces of differing tectonic and sedimentary history in the Silurian and Lower Devonian of Victoria: the Eastern Victorian Province where the Benambran and Bowning deformations and associated igneous activity left a profound imprint, and the Central Victorian Province where the effects of these periods of deformation are not so clearly defined and where vast tracts of poorly fossiliferous basin sediments formerly prevented extended unravelling of stratigraphic relationships.

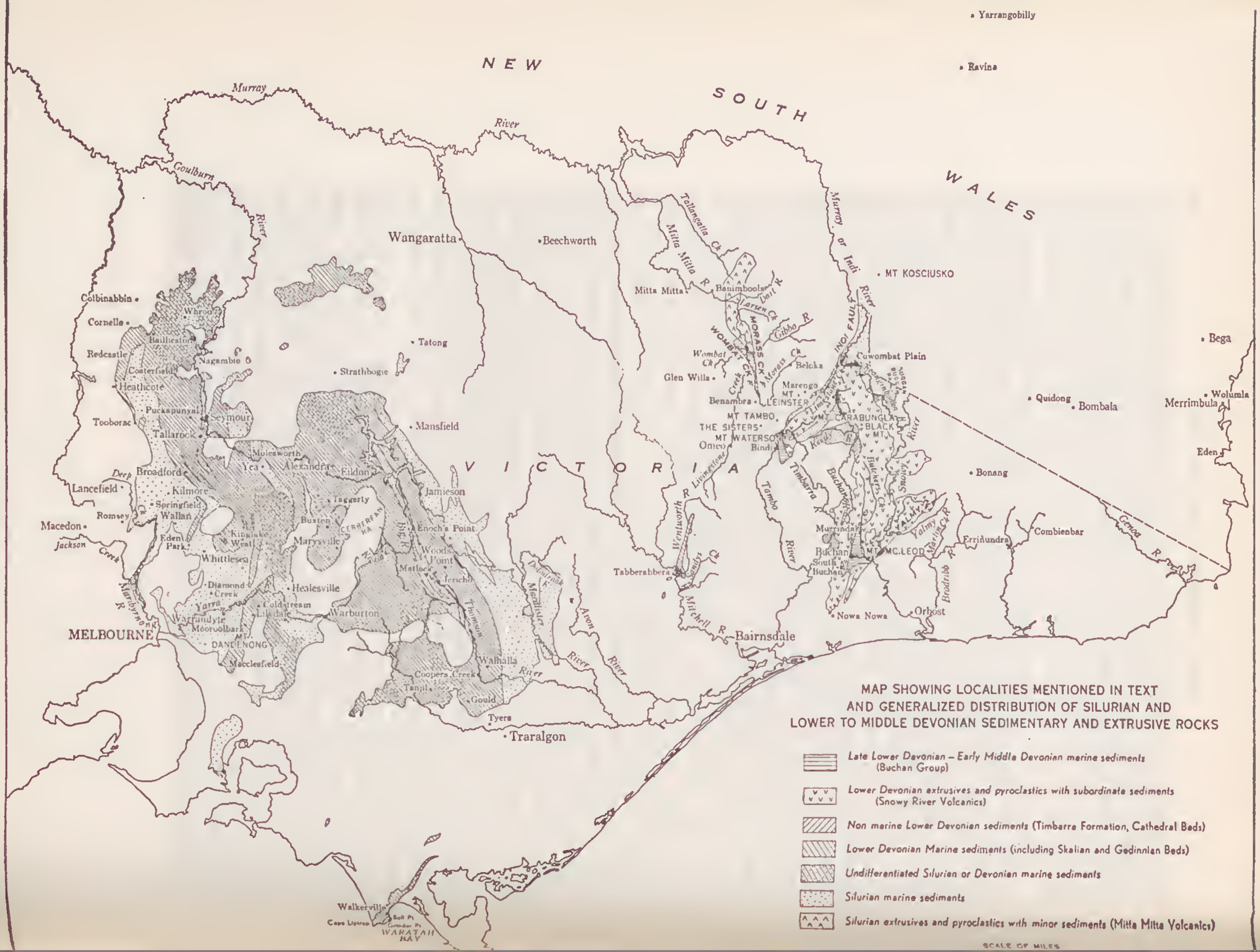
The Silurian and Devonian stratigraphy of C. Victoria can, for simplicity, be reduced to consideration of a relatively simple facies relationship within and between a series of major stratigraphic units. The lowest Silurian (Llandovery) Costerfield Formation at Heathcote (Thomas 1937) has as its approximate equivalents the Deep Creek and Springfield beds, known in detail in the Romsey-Lancefield district (Thomas 1960) and by reconnaissance southwards along the valleys of the Maribyrnong R. and Jackson's Ck. The Costerfield Formation is succeeded by the Wapentake Formation with the '*Illaenus* Band' at its base, spanning the interval between Upper Llandovery and the Lower Ludlow zone of *Monograptus nilssoni*; its equivalent farther S. is the Chintin Beds (Thomas 1960), here defined to extend upwards to the widely distributed graptolite beds of the Dargile Formation. Allowing for some uncertainty about correlation of its base with the base of the Wapentake Formation (the '*Illaenus* Band'), the Chintin Beds can be broadly considered a synonym of the Wapentake Formation and Unit 1 of the Dargile Formation. Recognition of the wide distribution of the Dargile Formation from Whroo and Bailliston NW. of Heathcote to the vicinity of Wallan N. of Melbourne, with its characteristic assemblages of graptolites in Unit 2 and association of *Aegiria thomasi* and *Encrinurus simpliciculus* in Unit 4 (Talent 1964), has been important in unravelling the structural and stratigraphic evolution of C. Victoria. Increase in sandstone and developments of conglomerates high in the Dargile Formation, as in the vicinity of Redcastle and Broadford, alternate with finer grained sediments notable for abundance of *Encrinurus* and *Aegiria*, as at Baillieston and Wallan. The Dargile Formation has not been clearly discriminated within the city of Melbourne, although its characteristic species have been found there.

The coarser Dargile sediments herald widespread deposition of sandstones of the McIvor Formation in the Cornella, Redcastle, Heathcote, and Tooberac districts. A gradual eastwards and southwards facies change within the McIvor Formation is discernible. The sequence through finer sediments and presumably to somewhat deeper water is: typical McIvor lamellibranch sandstones giving way to sandstones with lamellibranchs + rhynchonellids (principally *Stegerhynchus*) giving way in turn to fine sandstones and siltstones with *Isorthis*, *Plectodonta*, *Lissatrypa*, and *Pleurodictyum*. Farther out in siltstones these are joined by *Howellella*, *Leptaena*, asteroids and ophiuroids, *Atrypa 'reticularis'*, and *Maoristrophia*. Still farther away, *Macropleura* becomes important in siltstones as at Eden Park, Upper Plenty and Alexandra; in the Eildon district *'Conchidium'* and *Mucophyllum* occur within otherwise poorly fossiliferous, seemingly deep water equivalents of this unit, the Eildon Beds; the same beds along the Yea anticline have so far proved unfossiliferous. Recent mapping has shown that the lower part of the Humevale Formation (Williams 1964) is equivalent to the McIvor Formation and that the Mt Phillipa and Clonbinane members are good approximations to the base of the McIvor Formation in the Heathcote area (Schleiger & Talent MS.). It seems from our work that, broadly speaking, during the time of deposition of the McIvor Formation, the sea floor shelved down more or less evenly eastwards from the general vicinity of the Heathcote-Colbinabbin axis.

The faunas of the succeeding Mt Ida Formation (Talent 1964) at Heathcote are unique in Victoria. At least 6,000 ft of sandstones with interbedded mudstones, shales, and conglomerates bear a characteristic faunal succession dominated by the rhynchospirinid *Molongia*, the cuboidal rhynchonellid *Notoconchidium* and, in the uppermost unit, the *Pleurodictyum* beds, *Strophonella*, and *Meristella*. Remarkably similar sediments to those occurring at Redcastle and Heathcote outcrop from the Moorambool Fault through Puckapunyal to the vicinity of the Goulburn R.-Dabyminga Ck fault line where a rapid change to graptolitic facies occurs with frequent tongues of coarse conglomerates and sandstones echoing the essentially coarser sedimentation to the W. (Schleiger 1964b, Schleiger & Talent MS.). There is a somewhat less rapid facies change within the underlying McIvor Formation on either side of this old fault line, though here again there is a change eastwards to graptolitic sediments.

The Mt Ida faunas have been considered Lower Devonian in age for the past 20 years, but there has been uncertainty whether to include all or part of the McIvor within the Devonian. If the widely held contention that graptolites extend into the Devonian is correct, then part at least of the Mt Ida Formation is equivalent to Upper Gedinnian horizons at Seymour East containing monograptids close to *M. praehercynicus*. The oldest available stratigraphic name, the Wilson's Creek Shale (Thomas 1953) would take precedence for this portion of the graptolitic sequence if it could be precisely discriminated within the Humevale Formation (Williams 1964).

There are two important developments of plant-graptolite horizons about 8,000 ft apart in the Yea-Molesworth district. The upper of these contains *Monograptus*


MAP SHOWING LOCALITIES MENTIONED IN TEXT
AND GENERALIZED DISTRIBUTION OF SILURIAN AND
LOWER TO MIDDLE DEVONIAN SEDIMENTARY AND EXTRUSIVE ROCKS
Late Lower Devonian – Early Middle Devonian marine sediments (Buchan Group)
Lower Devonian extrusives and pyroclastics with subordinate sediments (Snowy River Volcanics)
Non marine Lower Devonian sediments (Timbarra Formation, Cathedral Beds)
Lower Devonian Marine sediments (including Skalian and Gedinnian Beds)
Undifferentiated Silurian or Devonian marine sediments
Silurian marine sediments
Silurian extrusives and pyroclastics with minor sediments (Mitta Mitta Volcanics)
SCALE OF MILES
NEW SOUTH WALES
VICTORIA
Yarrangobilly
Ravina
MT KOSCIUSKO
Bega
Quidong
Bombala
Merrimbula
Wolumla
Eden
Bonang
Combienbar
Erriñundra
Orbost
Nowa Nowa
Bairnsdale
Tabberabbera
Traralgon
Tyers
Wangaratta
Beechworth
Tatong
Mansfield
Strathbogie
Murray River
Goulburn River
Murray or Indi River
INDI FAULT
Cowombat Plain
Mitta Mitta
Mitta Mitta R
Tallangatta Ck
Banimboola
MORASS CK
WOMBAT CK
Wombat Ck
Gibbo R
Glen Wills
Benambra
Marengo
MT LEINSTER
MT TAMBO
THE SISTERS
MT WATERSON
Omeo
Bindi
MT CARABUNGLA
BLACK MT
Butchers Ck
Snowy River
Buchan R
Timbarra R
Tambo River
Murrindal
Buchan
South Buchan
MT MC.LEOD
Yalmy R
Brodribb R
Genoa R
Livingstone Ck
Wentworth R
Mitchell R
Avon River
Macalister River
Thomson River
Colbinabbin
Cornella
Redcastle
Whroo
Baillieston
Nagambie
Costerfield
Heathcote
Puckapunyal
Seymour
Tooborac
Tallarook
Broadford
Lancefield
Kilmore
Springfield
Wallan
Romsey
Macedon
Jackson Creek
Deep Creek
Eden Park
Whittlesea
Kinglake West
Molesworth
Yea
Alexandra
Eildon
Taggerty
Buxton
Marysville
CERBERAN RA
Jamieson
Enoch's Point
Big R
Woods Point
Matlock
Jericho
Walhalla
Coopers Creek
Tanjil
Gould
Healesville
Diamond Creek
Yarra
Warrandyte
Coldstream
Lilydale
Warburton
Mooroolbark
MT DANDENONG
Macclesfield
Maribyrnong R
MELBOURNE
Walkerville
Cape Liptrap
WARATAH BAY

GENERALISED EAST-WEST SECTION
TO SHOW
RELATIONSHIPS AND APPROXIMATE CORRELATIONS OF THE SILURIAN AND DEVONIAN FORMATIONS OF VICTORIA

Fig. 2

n. sp. close to *M. praehercynicus* and therefore correlates with part of the Wilson's Creek Shale; the lower contains *Monograptus* sp. indet. (Couper 1965); both are associated with plant remains including *Baragwanathia*. South-eastwards in the vicinity of Kinglake West, the Wilson's Creek Shale equivalents become more richly fossiliferous with chonetids, *Howellella, Notoleptaena, Notanoplia, Plectodonta, Nuculites*, ophiuroids, asteroids, carpoids, and trilobites, especially *Odontochile*, homalonotids, and *Dicranurus* (Williams 1964).

There is, in effect, a gradual transition from graptolitic to 'Yeringian' or shelly facies which persisted as the Ruddock Siltstone (Gill 1965) in the Lilydale-Killara area and, to a lesser extent, farther away contemporaneous with deposition of the graptolitic Wilson's Creek Shale and the succeeding Tanjil Formation and Walhalla Group to the N. and E. The localized neritic faunas in this south-westerly part of C. Victoria are an expression of less marked basin-style sedimentation (quasi-shelf environment) in this direction; the tendency of these faunas to fade out towards the N. and E. is believed to be due to deeper water in these directions.

The typical Tanjil formation, as developed at Tanjil (Thomas 1953) and farther N. at Matlock (Moore 1965), becomes more sandy northwards towards Eildon where equivalents of this unit bear the name Norton Gully Sandstones (Thomas 1947, 1953). The latter unit persists northwards from Eildon between the Wilson's Creek Shale and the Walhalla Group, but fossils characteristic of the Tanjil Formation* have not been recognized farther N. than Eildon. Possible intertonguing of Tanjil Formation with the 'Yeringian' units has already been recognized at Coldstream (loc. 28, Gill 1940), but its precise time significance relative to the typical *Nowakia-Styliolina* developments farther to the E. and NE. is not yet known.

[* We are using the name Tanjil Formation as being more in line with the original lithologic-cum-biostratigraphic intent of the term Tanjilian (Chapman 1914, 1924).]

Recent work on the monograptid and tentaculitoid faunas of the Eildon, Wilson's Creek, and Tanjil formations and their equivalents (Bouček & Jaeger MSS.) has indicated clearly the presence of three significant horizons. The lowest horizon contains, inter alia, *Monograptus aequabilis* (Pribyl) [formerly referred to as *M. vomerinus*], indicating an horizon either at the base of the Gedinnian or late in the Skala. Some 1,500 ft stratigraphically higher, and known from a wider distribution over a triangular area 70 miles by 50 miles, are beds containing a new species of *Monograptus* close to *M. praehercynicus* Jaeger, indicating an horizon higher in the Gedinnian and perhaps even Upper Gedinnian in age. Roughly 3,500 ft higher, in the Tanjil Formation, are horizons of *Panenka, Nowakia, Striatostyliolina*, and *Styliolina*. The species of *Nowakia*, known under the name *Tentaculites matlockiensis*, is identical with *N. acuaria* (Richter) and includes *Paranowakia intermedia* (?) (Barrande). This association indicates approximately the zone of *M. hercynicus* and certainly the higher part of the Lochkovian stage of the Bohemian succession (Bouček 1964, Zagora 1964). It is fairly clear that the *Nowakia-Striatostyliolina* beds of the Tanjil Formation are not older than Upper Gedinnian and are most probably Siegenian (cf. Solle 1963 for correlation of *M. hercynicus*). Correlation of the Boola Beds and the Coopers Creek Formation, some 3,500 ft stratigraphically higher, as most probably late Siegenian would agree on general grounds with published and unpublished work on the faunas of the Wentworth Group, the Waratah Limestone, and the Walhalla Group of the Eildon-Jamieson district. An Upper Ludlow or Lower Gedinnian age for the faunas of the Boola Beds and Coopers Creek Formation (Philip 1960a, 1962a, 1962b) is incompatible with this evidence.

Lateral variations in lithology within the Walhalla Group have yet to be adequately documented. In spite of widespread use as a marker horizon, the basal grits, conglomerates, and limestones of the Walhalla Group (Whitelaw 1916, Baragwanath 1925) are not always easy to locate and, though sedimentologically they represent an important event, they tend to be impersistent away from their maximum development about Coopers Creek and Tyers where they bear the name Coopers Creek Formation. It is sometimes overlooked that O. A. L. Whitelaw (1916) had commenced discrimination of two units within the Walhalla Group E. of Woods Point: a lower belt of slates with thin bands of sandstones—the Sir John Franklin Beds—succeeded by and, in part, lateral equivalents of the Johnson's Hill Sandstones.

West of the Walhalla Synclinorium, the Walhalla Group has been mapped in the Upper Yarra, Big R., and Eildon regions by Thomas (1947), Bell et al. (1959), and Moore (1965). The basal grits occur in the N. about Eildon and have been used as a marker horizon, but fade out southwards and appear to be absent in the Upper Yarra region. Rare horizons of shelly fossils, correlating broadly with the rich faunas within the Kilgower Member of the Tabberabbera Formation at Tabberabbera on the one hand and with the higher faunas at Lilydale (e.g. Gill 1942) on the other, indicate a Lower Emsian age for horizons 1,500 ft to 2,500 ft above the base of the Walhalla Group. Rhythmically banded fine-grained sediments occurring above the Tanjil Formation in the Upper Yarra area have been termed the Upper Yarra Formation (Moore 1965). They thus represent a departure in facies from the predominance of fine sandstones and siltstones outcropping on the W. side of the Walhalla Synclinorium about Jericho and Mt Matlock.

Recent mapping of the Cathedral Range and adjacent Lower Devonian sediments (Dale unpublished) has led to the discovery of a Lower Emsian fossil horizon approximately 3,500 ft stratigraphically below the base of the Cathedral Beds and more or less equivalent to horizons some thousands of feet above the base of the Walhalla Group elsewhere. Dale has confirmed the conclusion of E. S. Hills (1929) that the Cathedral Beds are conformable with the underlying typical Walhalla Group sediments; sandstones resembling those of the Cathedral Beds occur interbedded with Walhalla Group sediments for some distance beneath Unit 1 (first main sandstone) of the Cathedral Beds. The Cathedral Beds match lithologically the Koala Creek Beds outcropping to the E. of the Cerberean Volcanics Belt (Bell et al. 1959). Here again they overlie the Walhalla Group sediments in the Eildon Synclinorium and, despite poor outcrops and a faulted margin to the E., are assumed to have a similar relationship to the Walhalla Group. Therefore, we are led to the conclusion that the Cathedral Beds and the Koala Creek Beds, with their absence of fauna, their frequency of red beds, and poorly preserved flora, represent the regressive phase of the late Lower Devonian and perhaps early Middle Devonian sedimentation in C. Victoria.

As noted earlier, the 'Yeringian' or quasi-shelf facies tended to persist in the Lilydale-Killara area contemporaneous with deposition of the Tanjil Formation and the Walhalla Group elsewhere. A gradual overall shallowing of this essentially muddy sea floor, with its locally rich benthonic faunas, ultimately resulted in a true shelf environment with carbonate sedimentation and accumulation of the Lilydale Limestone characterized by rich Emsian (possibly Lower Emsian) stromatoporoid, coral, and gastropod faunas and with subordinate lamellibranch and brachiopod faunas. The Lilydale Limestone is overlain unconformably (Crohn 1950) by the poorly fossiliferous pebble- and boulder-bearing Cave Hill Sandstone.

Like the Cathedral Beds, it may be connected with regression of the seas from C. Victoria.

Eastern Victoria

The tectonic and sedimentary history of E. Victoria is more complex and, in many respects, is in contrast with that of C. Victoria, particularly during the Silurian, though some connection between the history of the two provinces in Lower Devonian times can be portrayed by the sequences at Waratah Bay and on the Mitchell and Wentworth R. Silurian sediments of E. Victoria outcrop principally about the headwaters of the Indi, Tambo, and Buchan R. A restricted development, the Wombat Creek Group, outcrops about the junction of the Gibbo and Mitta Mitta R. and is associated with an attenuate belt of Silurian volcanics—the Mitta Mitta Volcanics.

After being originally regarded as Silurian in age, the Wombat Creek Group was for many years thought to contain an intermingling of Silurian and Middle Devonian faunas (Chapman 1920), but re-investigation (Talent 1959a; Singleton & Talent MS.) has revealed that the entire sequence is of Silurian age. Whereas it had been thought that the basal conglomerates of the Wombat Creek Group rested unconformably on more tightly folded Ordovician sediments, investigation has shown a more complex situation. The Mitta Mitta Volcanics, extending as a meridional belt from the headwaters of Tallangatta Ck to the junction of the Gibbo and Mitta Mitta R., had been thought to be another body of similar age to the Snowy River Volcanics; recent work has shown them to underlie the Wombat Creek Group (Singleton 1965). Broadly speaking, the range of lithologies resembles that of the Snowy River Volcanics: rhyodacites, often highly fragmental, with subordinate rhyolites, tuffs, and minor generally tuffaceous sediments.

As one ascends the Mitta Mitta R. from its junction with the Gibbo R., successively higher horizons of the Wombat Creek Group are traversed until the sequence is truncated by a SE.-trending fault. The Wombat Creek Group commences with a basal sequence of over 1,000 ft of conglomerates containing occasional pebbles and boulders of Mitta Mitta Volcanics (Singleton 1965); rare fossil horizons include, inter alia, trimerellid brachiopods. This is overlain directly in most places, and with minor intervening sandstones in others, by a prominent limestone 300 ft or more in thickness, outcropping from beneath a mask of alluvium, gravel, hillwash, and Lower Tertiary basalt as a series of lenticles for about 5 miles; the limestones and associated fossiliferous shales have yielded a moderately rich fauna including species of *Mucophyllum*, *Propora*, and *Brachyprion*. The limestone is overlain by an unknown thickness, probably exceeding 1,500 ft, of generally fine-grained terrigenous sediments, including a minor development of conglomerate on the Mitta Mitta R. approximately ½ mile upstream from its junction with Wombat Ck (Whitelaw 1954, Fig. 2E); the horizon is noteworthy for the presence of occasional granitic boulders, testifying to the presence of pre-Wombat Creek Group granites. The sequence of terrigenous sediments is overlain by a limestone (Whitelaw 1954, Fig. 2F & G) containing, inter alia, halysitid corals; approximately the same horizon with poorly preserved halysitids and brachiopods outcrops in allotment 9, parish of Hinnomungie (Whitelaw 1954, Fig. 3D). The Wombat Creek Group is terminated by a sequence of sandstones and siltstones downthrown against Upper Ordovician graptolite-bearing sediments; these pass progressively to the S. and W. into the Omeo schists and gneisses. There is a remarkable contrast in tectonic style between the highly deformed, tightly folded Ordovician sediments and the fairly steep dipping though not tightly folded Wombat Creek Group. Evidence as well from the vast outpourings of Mitta Mitta Volcanics, many thousands of feet in thickness, and the enormous thickness of basal conglomerates of the Wombat Creek Group, indicates appreciable tectonic activity and, it would seem, strong folding of the Ordovician basement in Lower Silurian times (the Benambran Orogeny). The presence of granite pebbles and boulders within the Wombat Creek Group is clear evidence for pre-Wombat Creek Group granites. Granitic intrusions of this age are to be sought within the Omeo schists and gneisses *sensu lato*, but discrimination of granites of this antiquity will doubtless be difficult because of subsequent deformation by the Bowning and Tabberabberan movements. The Banimboola Granodiorite to the N., however, may be dated as pre-Middle Silurian. Road sections along the Mitta Mitta R. N. of Eustace Ck show Mitta Mitta Volcanics intrusive around huge, sometimes house-sized, blocks of granodiorite, demonstrating that the volcanics post-date the Banimboola Granite. Because the volcanics ante-date the Wombat Creek Group (much, if not all of which is no younger than Middle Silurian), the Banimboola Granite, or at least that part of it outcropping to the E. of the Mitta Mitta Volcanics belt between Eustace and Larsens Ck, is almost certainly of Lower Silurian (Llandovery) age.

Silurian sediments (the Cowombat Group) outcrop extensively about the headwaters of the Indi, Buchan, and Tambo R. (Talent 1959a; Talent, Bock, & Glenie 1964). They are overlain unconformably by the Snowy River Volcanics, but faulting and poor exposures have prevented clarification of their primary relationship to the Ordovician bedrock. The lowest unit, the Towanga Formation, consists of a vast thickness of generally fine sandstones or quartzites, seemingly exceeding 10,000 ft, with subordinate siltstones and lenticular limestones, the Caladenia and Farquhar limestone members. Higher in the Towanga Formation are lenticular bodies of conglomerate outcropping principally at Mt Carabungla (the Carabungla Member) and on the Indi R. between Copperhead and Bullies Ck. South-westwards towards Bindi, conglomerates dominate such an appreciable thickness of the succession (the Mt Waterson Formation) that, in the past, they were thought to be Upper Devonian in age; they overlie the largest development of limestone in the Cowombat Group, the Old Hut Limestone.

Stratigraphically higher than the Towanga Formation is the Cowombat Formation, composed typically of richly fossiliferous late Wenlock-early Ludlow siltstones and minor limestones at Cowombat and Native Dog plains, dominated by species of *Mucophyllum*, *Mazaphyllum*, *Fletcheria*, *Favosites*, *Heliolites*, and *Propora*, with rare *Atrypoidea*, *Atrypa*, and *Howellella*. Farther to the W. are numerous lenticular developments of limestone, the largest being given separate member status: the Sheehan Bluff, Claire Creek, and McCarty members. The rarity of fossils in these and their associated terrigenous sediments, the lenticular nature of the limestones, and the intervention of faults between them and the richly fossiliferous occurrences at Native Dog and Cowombat plains have prevented precise matching of horizons. The Cowombat Formation is terminated by unfossiliferous siltstones followed by at least 1,000 ft of unfossiliferous fine grained sandstones.

No Silurian volcanic rocks have been discriminated within the Cowombat Group though such may occur among the fault slices between Bindi and the headwaters of Limestone Ck. The Cowombat Group has been intruded by the Kosciusko Granodiorite, one long tongue of which serves to divide the two main outcrop belts of Towanga Formation. The adjacent sediments, generally, have been weakly metamorphosed; what is obviously metamorphosed Towanga Formation on the Suggan Buggan Ra. and the Toonginbooka R. has been discriminated as the

Suggan Buggan Schists (Talent, Bock, & Glenie 1964). As the Cowombat Group contains faunal equivalents of the Bowspring Limestone and the Barrandella Shale and still younger unfossiliferous horizons, the earliest date for deformation of the Cowombat Group can scarcely precede the top of the Silurian. Yet deformation had taken place and has been followed by intrusion of granodiorite and extensive unroofing of the batholith before deposition of the Timbarra Formation (5,000+ ft), followed in turn by extrusion of the Snowy River Volcanics, with its many hiatuses, prior to deposition of the late Emsian or early Eifelian Buchan Caves Limestone.

Silurian sediments have been found sub-surface beneath the Snowy River Volcanics in the parish of Nowa Nowa South (Talent 1959b) and outcrop again in a little known belt between Martin's Ck and the head of Sardine Ck (Stirling 1888). These occurrences, together with those of the Cowombat and Wombat Creek groups, are indicative of basin sedimentation, presumably in different parts of the same basin. Analogous thick sequences of Silurian sediments are found farther N. in New South Wales, in particular in the Yarangobilly-Ravine-Tumut Pond area. This style of sedimentation contrasts to some extent with that at Quidong, about 12 miles W. of Bombala, where richly fossiliferous limestones and associated shales, correlating broadly with the Cowombat Formation, indicate an approach to more shelf-like conditions; the basal sequence of sandstones there is an echo of the Towanga Formation of the Cowombat Group.

The Silurian sequences of E. Victoria contrast with the succession in C. Victoria. Lower Silurian (Llandovery) graptolitic sediments, seemingly conformable with Ordovician sediments (Thomas & Keble 1933), outcrop in the watersheds of the Maribyrnong R. and its tributaries W. of Melbourne, Warrandyte, Diamond Ck, Macclesfield, Enoch's Point, and a locality on the Dolodrook R. For younger horizons there is an expanding gap in palaeontological knowledge as one goes eastwards, the lowest fossiliferous post-Llandovery beds becoming younger (Fig. 1). This gap may be connected with the breaks in sedimentation to be expected from an eastward increase in intensity of deformation associated with the Benambran and later movements approximating the Bowning deformation in E. Victoria.

This deformation was followed by the intrusion and de-roofing of the Kosciusko Batholith. Thick sequences of non-marine conglomerates, sandstones and siltstones, and minor ignimbrites, at least 5,000 ft in thickness, the Timbarra Formation, were deposited between Buchan and Black Mountain (Fletcher 1963, E. A. Woodford pers. comm.). Subsequently the Snowy River Volcanics complex of more than 10,000 ft of rhyodacites and tuffs, with subordinate rhyolites, andesites, keratophyres, and basalts accumulated over much of Victoria E. of the Tambo R. Evidence from Bindi, best seen at Mt Waterson, shows that the Snowy River Volcanics and the underlying Cowombat Group were subjected to block faulting and planation prior to deposition of the Buchan Group, the lowest unit of which rests indiscriminately over the planed surfaces of blocks of Snowy River Volcanics and Cowombat Group. It would seem that other parts of the Snowy River Volcanics belt were subjected to block faulting prior to deposition of the Buchan Group, most notably the belt from Nowa Nowa through Mt McLeod to the vicinity of Butchers Ck, where a jig-saw of blocks of Ordovician sediments and pre-Devonian granite is interrupted by a cover of Buchan Group sediments which are, by comparison, little disturbed. Post-Middle Devonian tear faulting and thrusting on this same belt has been much less severe than what must have occurred prior to deposition of the Buchan Group.

Subsidence of the more or less planar Buchan-Indi-Combienbar area led to deposition of the remarkably uniform Buchan Caves Limestone covering at least 2,500 square miles, though now represented by a series of some 14 discrete tectonically preserved enclaves, commencing typically with a basal sequence of dolomites (the Spring Creek Member), exceeding 200 ft in the SE. at South Buchan, but thinner in the W. at Bindi and in the three enclaves along Limestone Ck. The Buchan Caves Limestone is overlain by the Taravale Formation which, in turn, is in facies relationship with the Murrindal Limestone. A prominent tongue of Taravale Formation, the Pyramids Member, separates the Murrindal and Buchan Caves limestones in the Buchan-Murrindal area.

Faunas typical of the Pyramids Member at Buchan occur at the top of the Buchan Caves Limestone at Bindi. The presence of *Adolfia* in abundance and the bizarre ostracode genus *Poloniella*, of *Calceola sandalina*, *Nadiastrophia* n.sp., and *Aulacella* indicate an Eifelian or possibly late Emsian horizon; this is in agreement with indications from goniatite faunas occurring in the first 600 ft or so of the Taravale Formation at Buchan. Higher in the sequence, in the Murrindal Limestone, a further species of *Calceola* (a tiny one), a new genus resembling *Leptodontella, Cyrtinopsis*, a new genus of rhynchonellid to include the Eifelian *Hypothyridina procuboides*, and a variety of new genera of rhynchonellids of Eifelian aspect occur. The great thickness of poorly fossiliferous Taravale Formation at Buchan (2,500+ ft) and at Bindi (3,500+ ft) indicates the possibility of the Buchan Group ascending even into the Givetian.

The Snowy River Volcanics at Errinundra (Thomas 1949) are very similar to the Snowy River Volcanics in the vicinity of Buchan, but the sequence is much reduced and has a higher proportion of sediments including deformed marine fossils (chiastolite slate stage); it is overlain by metamorphosed Buchan Caves Limestone. It would appear from evidence at Errinundra that the Snowy River Volcanics were fading out eastwards into marine conditions. This leaves for consideration two areas which, in varying respects, help to relate the structural and biostratigraphic history of the two provinces.

At Waratah Bay two main carbonate formations can be discriminated, separated by an unconformity coinciding with a total faunal break between the two formations. This has been overlooked by previous workers and has led to some confusion. The lower horizon, the Waratah Limestone, has already been divided into three members (Teichert 1954). At Grinder Point it rests with a clearly exposed unconformity (Thomas & Singleton 1956) directly on to a Cambrian sequence without intervention of Ordovician or Silurian rocks. The detritus in the basal beds has been derived entirely from Cambrian rocks. The faunas of the Waratah Limestone at Grinder Point, at Mushroom and Gair Rocks, Bell Point, and of the Kiln and Bird Rock members at Walkerville have a strong resemblance in faunas of stromatoporoids, tabulate and rugose corals and, to a lesser extent, molluscs and brachiopods to the faunas of the Coopers Creek Formation and the basal beds of the Walhalla Group. This indicates that the event connected with the subsidence and initiation of carbonate sedimentation on the Cambrian horst at Waratah Bay corresponds with the event responsible for the dumping of conglomerates and the accumulation of lenticular limestones at the base of the Walhalla Group. In this regard it is of interest to record the abundance of Cambrian detritus in the latter, particularly about Gould, where parts of the unit correspond in composition and appearance to a basaltic or diabasic tuff (Thomas 1942), and thereby indicate the presence of exposed Cambrian rocks in the vicinity at that time.

The Bell Point Limestone at Bell Point can be seen to overlap the Waratah

Limestone with a low angle of unconformity on the W. face of Gair Rock. The weathered surface of the Waratah Limestone at that time is obvious; boulders of Waratah Limestone have been incorporated in the basal beds of the Bell Point Limestone, the proximal ends of the beds being packed with irregular boulders of Waratah Limestone. The break in deposition indicated by this unconformity represents an appreciable length of time, for there is an almost complete disparity between the faunas above and below this break. The brachiopod faunas of the Bell Point Limestone, being the same as those of the Buchan Caves Limestone, indicate that the widespread subsidence associated with the change to marine conditions and deposition of the Buchan Caves Limestone on the Indi-Combienbar-Buchan shelf was felt at Waratah Bay, where marine carbonate sedimentation was resumed after a period of non-deposition and apparently of erosion.

The Bell Point Limestone is not represented at Walkerville, but the Waratah Limestone there extends to higher horizons (the Bluff Member) than at Bell Point or Grinder Point. This presumably indicates loss of the Bluff Member by greater erosion at Bell Point than occurred at Walkerville during the interval prior to deposition of the Bell Point Limestone.

It is remarkable that this break in sedimentation at Waratah Bay correlates broadly with the period of block faulting and planation prior to deposition of the Buchan Caves Limestone over the Buchan-Indi-Combienbar shelf of E. Victoria, and to the possible interruption in sedimentation between the Kilgower and Roaring Mag members of the Devonian succession at Tabberabbera. This again is indicated by a sharp break in the faunal succession, with possible northwards onlap of the Roaring Mag Member on to successively older horizons of the Kilgower Member and with rapid wedging out northwards of the upper sandstones of the Kilgower Member.

Correlation of the Liptrap Formation (Lindner 1953) has been problematical, for it is separated from the outcrops of Devonian limestones on the Cambrian belt by the Walkerville Fault and, moreover, there are no enclaves of Liptrap Formation within the Cambrian belt. It consists of somewhat more than 5,000 ft. of detrital sediments with a few slump conglomerates containing tabulate corals, a few rugose corals and rare brachiopods. The unconformities within and below the Devonian limestones on the Cambrian belt lack Liptrap sediments and, therefore, it might appear at first glance that the latter is perhaps younger than any of the Devonian carbonate units. On the other hand, the striking abundance of Cambrian detritus: chert, jasper, and greenstones within the conglomeratic parts of slumped beds indicates that parts at least of the adjacent Cambrian horst were exposed and acting as sources for part of the components of the nearby Liptrap Formation. Boulders, seemingly of Waratah Limestone, collected from these slumps, on the other hand, would suggest some cover of carbonate sediments over part of the Cambrian horst during accumulation of part at least of the Liptrap Formation, thereby removing the possibility that deposition of the Liptrap Formation occurred prior to deposition of the Waratah Limestone. The faunal evidence is meagre and equivocal, there being no known fossil horizons where it can be reasonably assumed that the fauna is more or less in situ. Though some beds are rich in tabulate corals, the latter are invariably worn and broken by transport. Lumps of *Heliolites daintreei, Phillipsastraea maculosa, Favosites goldfussi,* and *F. squamuliferus nitidus* are in accord with derivation from the Waratah Limestone; the occurrence of *Heliophyllum*, a supposed Middle Devonian genus, is no longer anomalous for a somewhat similar form occurs at Tyers (Philip 1962a) in beds correlating with the Kiln and Bird Rock members of the Waratah Limestone. It is suggested that deposition of the

Liptrap Formation coincided with the break between the Waratah and Bell Point limestones and that, during this interval, there was erosion of the Waratah Limestone revealing tracts of Cambrian rocks which then acted as sources for the Cambrian detritus in the Liptrap Formation. This is in accord with a distinct parallel in lithology with the sediments of the Walhalla Group above the Coopers Creek Formation (a correlate of the Waratah Limestone), and the presence of a comparable flora in the Centennial Beds of the Walhalla Group with that in the Liptrap Formation at Livingstone Ck (Lang & Cookson 1930). The conglomeratic slump beds of the Liptrap Formation are analogues of the 'grit bands' (e.g. Waterloo Gully Grit) of the Walhalla Group. The Liptrap Formation is then a south-westward extension of the Walhalla Group as developed in the Walhalla Synclinorium.

The Liptrap Formation and the Waratah Limestone, particularly the Bird Rock and Kiln members, in many respects echo the sedimentation of the Central Victorian province. On the other hand, the Bell Point Limestone and the two unconformities reflect the tectonic and sedimentary history of the Eastern Victorian province.

The Devonian succession on the Mitchell and Wentworth R. (Talent 1959a, 1963) rests with marked angular unconformity on folded Upper Ordovician sediments without the intervention of a Silurian sequence to help discriminate between deformation due to the Benambran and Bowning movements. The lowest fossiliferous unit, the Wild Horse Formation, contains a poorly preserved and essentially undescribed fauna recalling that of the Coopers Creek Formation, indicating that the event responsible for the accumulation of limestones and conglomerates over such a wide area about the base of the Walhalla Group found expression at Tabberabbera in subsidence and marine deposition of thousands of feet of essentially terrigenous sediments. This event is to be compared with the contemporaneous subsidence and deposition of the Waratah Limestone unconformably over Cambrian greenstones at Waratah Bay. Higher in the succession within the Kilgower Member at Warrigal Bend, Sandys Ck, and at locality 35 at Tabberabbera, there occur faunas of Lower Emsian aspect more or less equivalent to horizons 1-2,000 ft above the base of the Walhalla Group. The upper sandstones of the Kilgower Member wedge out northwards from Sandys Ck to Tabberabbera; this may be the expression of a break in deposition within the Wentworth Group between the Kilgower and Roaring Mag members mentioned earlier.

The Wentworth Group was rather strongly folded and intruded by the Tabberabbera Dyke Swarm and there had been extensive planation prior to deposition of the comparatively flat-lying non-marine Avon River Group sediments with their interbedded lava flows. The folding during this interval (the Tabberabberan Orogeny) affected all known occurrences of Lower to Middle Devonian sediments in Victoria. The deformation was associated with large scale faulting, no doubt in part along pre-existing fault lines, e.g. the East Buchan Thrust and its associated belt of deformation follows a pre-Buchan Group fault belt affecting blocks of Snowy River Volcanics, Ordovician sediments, and pre-Devonian granitic rocks. Movement occurred along some of the largest faults in E. Victoria at this time, though in most cases the absence of adjacent Upper Palaeozoic sediments prevents discrimination of post-Tabberabberan movements, e.g. the Yalmy R., Gillingall, Murrindal faults. The notable exception is the Indi Fault running northwards from the vicinity of Bindi and into New South Wales along the W. flank of Mt Kosciusko where the fault zone is well exposed along the Alpine Highway; it then joins the fault systems of the Snowy Mountains (Moye, Sharp, & Stapledon 1963). There have been no discernible post-Palaeozoic movements along the Indi Fault in Victoria [it should not be confused with the geomorphic lineament termed the Limestone Creek Fault by Crohn (1950) which lies obliquely across the arcing trend of the Indi Fault]. Net movements along the Indi Fault during the Tabberabberan deformation resulted in the downthrow to the E. and preservation of a vast thickness of Cowombat Group, Snowy River Volcanics, and Buchan Group sediments adjacent to the fault, whereas all of these units were completely removed from adjacent parts of the upthrown block to the W. Upper Devonian times witnessed the deposition of a great thickness (10,000+ ft) of non-marine terrigenous sediments, the Mt Tambo Group, presumed to correlate with the Avon River Group. Subsequent movement was the reverse of that oecurring during the Tabberabberan deformation, resulting in preservation of the Mt Tambo Group on the downthrown W. side of the Indi Fault and the complete stripping of this unit from the upthrown E. side. The overall displaeement in relation to Tabberabberan and later, presumably Kanimblan, movements was one of downthrow to the E. The controversy at Bindi between A. W. Howitt and James Stirling (for literature see Gaskin 1943) on the relationships of the 'Bindi Limestone' (= Buchan Group) and the 'Mt Tambo Beds' (= Mt Tambo Group) is now seen to be due to Howitt not having diseovered the Indi Fault between the two lithologic units and learned its history of reversal of movements. Stirling, who was long eonsidered to have lost the argument, eorrectly interpreted the relationships between the limestones of Old Hut Ck and the conglomeratic sediments at Mt Waterson, Bindi, but was in reality dealing with the relationships between two Silurian formations uneonformably underlying the 'Bindi Limestone'.

Orogensis and Granitic Emplacement

Until recently it was customary to eonnect igneous activity in SE. Australia with one or other of a number of discrete periods of deformation, but recent potassium-argon dates for the S. part of the Tasman Geosynelinc failed to show the clearly defined cycles one would expect if this had been so (Evernden & Richards 1962). It is uneertain at this stage whether the cyclie nature of the granitic emplacement has tended to be obscured by (1) the reconnaisance nature of this survey over such a wide area and by (2) subsequent deformation and reheating of some of the sampled localities by later movements. Depending on the ages ehosen for systemic boundaries, the oldest of the six granitie rocks sampled in E. Victoria could be as old as about the Llandovery-Wenloek boundary. Doubt was cast on the presenee of granitie rocks associated with the Benambran deformation, but the oecurrence of granitie boulders within the Wombat Creek Group is alone sufficient evidence for some Lower-eum-early Middle Silurian or older granitie emplaeement in this part of the Tasman Geosyneline. As indicated earlier, there are other granitie bodies in E. Victoria which may be pre-Wombat Creek Group in age. As already indicated (Talent 1959a), some of the granitic intrusions of E. Vietoria, particularly those intruded immediately after the Bowning deformation, ean be dated on stratigraphie grounds. It is expected that sampling of the granitic intrusions of C. Victoria, along with selected granitic bodies in E. Vietoria, would have produced something of a maximum for Upper Devonian times. The youngest granitic rocks from Victoria so far dated are of late Triassic age (MeDougall in Singleton 1965). The extent to which granitie emplacement in Victoria shows cyelic eharacteristes is still an open question.

Summary of Middle Palaeozoic Events

1a. Strong deformation (Benambran Orogeny) of the pre-Silurian (Eastonian and older) sequence of E. Victoria, contemporaneous with:

1b. Deposition of graptolitic terrigenous sediments in C. Victoria following on unabated from the Upper Ordovician, seemingly without structural complication.

2a. Intrusion of post-Eastonian pre-Wenlockian granites in E. Victoria indicated by granitic boulders within the Wombat Creek Group. This is assumed to be the time of intrusion of the Banimboola Granite, the generation of the Omeo schists and gneisses *sensu stricto*, and intrusion of some of its associated concordant granitic bodies. This was concurrent with:

2b. Uninterrupted sedimentation in C. Victoria.

3. Extrusion of the Mitta Mitta Volcanics.

4a. Deposition of vast thicknesses of essentially terrigenous sediments (Wombat Creek Group, Cowombat Group) in E. Victoria commencing with great thicknesses of basal conglomerates and sandstones.

4b. Uninterrupted deposition of virtually unfossiliferous marine terrigenous sediments (Wapentake Formation) in C. Victoria during Wenlockian times.

5a. Continued deposition of the Cowombat Group in E. Victoria into Lower Ludlow times, concurrent with:

5b. Deposition of the Dargile Formation (including the zone of *Monograptus nilssoni*) and its equivalents over a large area of C. Victoria in Lower Ludlow times.

6a. Deformation of the Cowombat and Wombat Creek groups at a time probably approximating that of the Bowning deformation in New South Wales; broadly concurrent with:

6b. Widespread deposition of the McIvor Formation in the Seymour-Heathcote-Whroo area in late Ludlow-Skalian-Lower Gedinnian times.

7. Intrusion of the main granitic bodies of E. Victoria, e.g. the Kosciusko Granodiorite, contemporaneous with part or all of events 8 and 9.

8. Deposition of the Mt Ida Formation not far removed from the W. shore line of the early Devonian sea in Upper Gedinnian times following on without a break from the McIvor Formation and contemporaneous with accumulation of plant-graptolite facies over a broad area of C. Victoria E. of a line through Seymour and Healesville. Quasi-shelf conditions at this time supported benthonic faunas about Kinglake West.

9. Widespread deposition of the Tanjil Formation in C. Victoria in Siegenian times contemporaneous with the existence of quasi-shelf conditions about Lilydale and Killara.

10. Deroofing of the Kosciusko Granodiorite and its extensions in E. Victoria followed by:

11. Accumulation of 5,000+ ft of Timbarra Formation associated with minor igneous activity.

12. Extrusion of the Snowy River Volcanics—10,000+ ft of rhyodacites and subordinate rhyolites, dacites, keratophyres, and basalts and a large volume of tuffs with subordinate lacustrine sediments and minor marine intercalations at Buchan and Errinundra. Events 10-12 were contemporaneous with:

13a. Uninterrupted sedimentation in C. Victoria with accumulation of the middle part of the Ruddock Siltstone contemporaneous with:

13b. Subsidence and deposition of the Waratah Limestone unconformably over the Cambrian complex at Waratah Bay.

13c. Deposition of conglomerates and lenticular limestones at the base of the Walhalla Group giving way to rapid accumulation of poorly fossiliferous terrigenous sediments (lower Walhalla Group).

13d. Subsidence of the area about the Mitchell and Wentworth R. in Upper Siegenian times followed by marine deposition of the Wild Horse Formation and of the Dead Bull and Kilgower members of the Tabberabbera Formation.

14a. Uninterrupted sedimentation in C. Victoria with accumulation of the highest beds of the Ruddock Siltstone and the Lilydale Limestone.

14b. Erosion of some of the Waratah Limestone off the Waratah Axis contemporaneous with deposition of the Liptrap Formation.

14c. Block faulting of the Snowy River Volcanics and planation.

15a. Regression of the seas from C. Victoria indicated by the Cathedral Beds and Cave Hill Sandstone.

15b. Subsidence of much of E. Victoria with deposition of the essentially terrigenous Roaring Mag Member at Tabberabbera, and deposition of the Buchan Caves Limestone over the eroded surfaces of blocks of Snowy River Volcanics and Cowombat Group on the Buchan-Indi-Combienbar shelf.

15c. Resumption of carbonate sedimentation (Bell Point Limestone) on the Waratah Axis.

16. Accumulation of the Taravale Formation in facies relationship with the Murrindal Limestone.

17. No record of Givetian sediments.

18a. Deformation throughout the State (Tabberabberan Orogeny) at some time in the interval post-Eifelian to some time in the Upper Devonian.

18b. Tectonically controlled intrusion of the Woods Point and Tabberabbera dyke swarms.

18c. Movements along major faults in E. Victoria, particularly those associated with the Snowy River Volcanics belt, e.g. Indi Fault.

19a. Denudation concurrent with accumulation of non-marine Upper Devonian sediments over uneven surfaces in E. Victoria. Extrusion of minor rhyolites in the Mt Tambo Beds, but with greater development of rhyolites and basalts farther W. in the Avon River Group.

19b. Extensive volcanic outpourings, partly from ring fractures, in C. Victoria, to be intruded subsequently by their parent magmas at some time close to the Devono-Carboniferous boundary.

20. At undetermined later dates (? Carboniferous) tilting of the Mt Tambo Beds and renewed movement along the Indi Fault with downthrow to the W., the reverse of movements associated with the Tabberabberan Orogeny.

21. Intrusion of the granite-porphyrys (e.g. The Sisters Granite) and syenites of the Benambra-Marengo-Beloka area in late Triassic times.

Cited Literature

BARAGWANATH, W., 1925. The Aberfeldy district, Gippsland. *Mem. Geol. Surv. Vict.* 15: 7-39, Pl. 1-19.

BELL, G., CROHN, P. W., THOMAS, D. E., HARRIS, W. J., and WHITELAW, O. A. L., 1961. Jamieson area (map). Geol. Surv. Vict.

BOUČEK, BEDRICH, 1964. The Tentaculites of Bohemia. 215 p., 40 pl.

CHAPMAN, FREDERICK, 1914. On the palaeontology of the Silurian of Victoria. *Rep. Aust. Assoc. Adv. Sci.* 14: 207-235.

————, 1920. Palaeozoic fossils of eastern Victoria. Pt 4. *Rec. Geol. Surv. Vict.* 4: 175-194, Pl. 16-32.

————, 1924. On the question of the Devonian age of the Tanjilian fauna and flora of Victoria. *Rep. Aust. Assoc. Adv. Sci.* 17: 313-318.